5.16.12 STANDARD COMPACTION TEST (Kansas Test Method KT-12)

a. SCOPE

a.1. Fine Grained Materials (**d.**): This method of test is used to determine the relation between the moisture content and density of soils or other fine grained materials when subjected, at various moisture contents, to a standard compactive effort while confined in a rigid metal mold. **KT-12** reflects testing procedures found in AASHTO T 99.

a.2. Granular Materials (**e.**): This method of test is used to determine the relation between the moisture content and density of granular materials, when subjected, at various moisture contents, to a standard compactive effort while confined in a rigid mold. **KT-12** reflects testing procedures found in AASHTO T 99.

The procedure for compaction of "fine grained materials" shall be followed whenever:

(1) The material has less than 10% retained on the No. 4 (4.75 mm) sieve, or

(2) The material has more than 10% but less than 30% retained on the No. 4 (4.75 mm) sieve and the plastic index of the fraction passing the No. 40 (425 μm) sieve is greater than 8.

Granular materials are classified as materials passing the $^{3}/_{4}$ in (19.0 mm) sieve.

b. REFERENCED DOCUMENTS

b.1. KT-11; Moisture Test

b.2. AASHTO M 231; Weighing Devices Used in the Testing of Materials

b.3. AASHTO T 19; Unit weight and Voids in Aggregate

b.4. AASHTO T 99; The Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop

b.5. AASHTO T 265; Laboratory Determination of Moisture Content of Soils

b.6. ASTM D 2168; Test Methods for Calibration of Laboratory Mechanical-Rammer Soil Compactors

c. APPARATUS

c.1. Fine Grained Material:

c.1.a. Mold. The mold shall be solid wall, metal cylinders 4 in (101.6 mm) with a capacity of 1/30 (0.0333) ± 0.0003 ft^3 (0.000943 ± 0.000008 m^3) and an internal diameter of 4.000 ± 0.016 in (101.60 ± 0.41 mm) and a height of 4.584 ± 0.005 in (116.43 ± 0.13 mm). It shall have a detachable collar assembly approximately 2.375 in (60 mm) in height. The mold and collar assembly shall be constructed so that it

can be fastened firmly to a detachable base plate made of the same material. The base plate shall be plane to 0.005 in.

c.1.a.1. A mold that fails to meet manufacturing tolerances after continued service may remain in use provided those tolerances are not exceeded by more than 50 percent; and the volume of the mold, calibrated in accordance with AASHTO T 19 Section 7, for Unit Mass of Aggregate, is used in the calculations.

c.1.a.2. Any correction to the volume requires a new calculated multiplier (F). The multiplier is an inverse function of the mold volume.

NOTE: The volume of the mold (without the collar) is measured by coating one end with cup grease or vaseline to form a seal and then placing it on a glass plate which should be placed in a level position on a scale. The other end of the mold is coated with cup grease or vaseline and then the mold and two glass plates are weighed. The mold may then be filled with 77 ± 2°F (25 ± 1°C)[1] water after which the second glass plate should be placed on top of the mold in such a way as to eliminate air bubbles and excess water. Any excess water thus removed must be carefully wiped off after which the final weight of the mold, water and glass plates may be determined. The volume of the mold may then be calculated using 62.243 lb/ft^3 (997 kg/m^3) as the density of water.

c.1.b. Rammer

c.1.b.1. Manually operated. Metal rammer with a mass of 5.5 ± 0.02 lb (2.495 ± 0.009 kg), and having a flat circular face of 2.000 in (50.80 mm) diameter with a tolerance of ± 0.01 in (0.25 mm). The in-service diameter of the flat circular face shall be not less than 1.985 in (50.42 mm). The rammer shall be equipped with a suitable guide-sleeve to control the height of drop to a free fall of 12.00 ± 0.06 in (305 ± 2 mm) above the elevation of the soil. The guide-sleeve shall have at least 4 vent holes, no smaller than 3/8 in (9.5 mm) diameter spaced at 90 degrees (1.57 rad) apart and ¾ in (19 mm) from each end; and shall provide sufficient clearance so the free fall of the rammer shaft and head is unrestricted.

c.1.b.2. Mechanically Operated. A mechanically operated metal rammer is equipped to control the height of drop to 12 $\pm$ 0.006 in (305 $\pm$ 2.0 mm) above the elevation of the soil and to distribute the blows over the soil surface. The rammer has a 2 inch (50.8 mm) diameter, flat circular face and has a mass of 5.5 $\pm$ 0.02 lb (2.495 $\pm$ 0.009 kg).

NOTE: The mechanically operated rammer must be calibrated as directed by ASTM D 2168, Method A.

c.1.c. Sample Extruder (desirable): Frame, jack and circular metal loading plate or other device for removing specimens from the mold.

c.1.d. Balances: One balance or scale conforming to AASHTO M 231 Class G 20. And one balance conforming to AASHTO M 231 Class G 2.

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[1] AASHTO T 99 references AASHTO T 19 to calibrate the mold. AASHTO T 19 permits the use of varying temperatures 77 ± 2°F (25 ± 1°C) with correction factors to compensate for the water density. By using the fixed temperature requirement, KDOT uses a single value (62.243 lb/ft^3 [997 kg/m^3]) for the density of water during the calibration of such apparatuses.±

c.1.e. Drying oven: A thermostatically controlled drying oven capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C) for drying moisture samples.

c.1.f. Straight edge: A hardened-steel straightedge at least 10 in (250 mm) in length. It shall have one beveled edge, and at least one longitudinal surface shall be plane within 0.01 in per 10 in (0.250 mm per 250 mm) (0.1 percent) of length within the portion used for trimming the soil.

c.1.g. No.4 (4.75 mm) sieve.

c.1.h. Drying pans.

c.1.i. Trowels, spatulas and other mixing tools or a mechanical mixer that will thoroughly mix the material and water.

c.2. Granular Material:

c.2.a. Mold: The mold shall be solid wall, metal cylinders 6 in (152.4 mm) with a capacity of 0.07500) ± 0.00075 ft^3 (1/13.33 (0.002124 ± 0.000021m^3) and an internal diameter of 6.000 ± 0.026 in (152.40 ± 0.66 mm) and a height of 4.584 ± 0.005 in (116.43 ± 0.13 mm). It shall have a detachable collar assembly approximately 2.375 in (60 mm) in height. The mold and collar assembly shall be constructed so that it can be fastened firmly to a detachable base plate made of the same material. The base plate shall be plane to 0.005 in.

c.2.a.1. See Section **c.1.a.1.** for mold acceptability.

c.2.b. Straight edge: A hardened-steel straightedge at least 10 in (250 mm) in length. It shall have one beveled edge, and at least one longitudinal surface shall be plane within 0.01 in per 10 in (0.250 mm per 250 mm) (0.1 percent) of length within the portion used for trimming the soil.

c.2.c. Other apparatus as listed under **c.1.**

NOTE: When a mechanical compactor is used, the 2 in (50.8 mm) diameter circular face foot may be replaced with a rigid "pie-shaped" foot. The "pie-shaped" foot shall be a sector of a 6 in (152.4 mm) diameter circle and shall have an area equal to that of the circular foot.

d. FINE GRAINED MATERIALS

d.1. Sample Preparation.

d.1.a. Obtain a 60 to 80 lb (30 to 35 kg) sample, dry at 140^0 F (60^0 C) if necessary, and break it down to pass the No. 4 (4.75 mm) sieve. Discard granular particles retained on the sieve.

d.1.b. Mix thoroughly and weigh out six portions, each weighing 5 lb (2200 g).

d.2. Test Procedure.

d.2.a. Add a measured amount of water (approximately 12 percent by dry mass) to one 5 lb (2200 g) portion and thoroughly mix it into the sample.

THE SAMPLE OF SOIL-WATER MIXTURE SHALL BE PLACED IN A CLOSED CONTAINER TO MINIMIZE MOISTURE LOSS. THE SAMPLE SHALL THEN BE ALLOWED TO STAND FOR A MINIMUM OF 12 HOURS BEFORE CONDUCTING THE MOISTURE DENSITY TEST.

d.2.b. Place the assembled mold on the rigid base and fill the mold so that the compacted layer will equal $^1/_3$ of the mold volume.

d.2.c. Compact the material with 25 blows of the rammer dropped from a height of 12 in (304.8 mm) above the surface of the material. Distribute the blows of the rammer evenly over the surface.

d.2.d. Place two more layers of the material in the mold and compact each layer as stipulated in **d.2.c.** above.

d.2.e. Remove the top collar and trim the excess material level with the top of the mold.

d.2.f. Remove the base and trim excess material level with the bottom of the mold.

d.2.g. Weigh the sample to the nearest 5 g while it is in the mold and multiply the mass of the sample and the mold, minus the mass of the mold, by 30 (1060), and record the result as the wet density, W_1, in pounds per cubic foot, (kilograms per cubic meter), of the compacted soil.

d.2.h. Repeat the compaction procedure using the other 5 lb (2200 g) increments of the sample to which different measured amounts of water have been added, thoroughly mixed and cured as in the note following **d.2.a.** This procedure will be continued with varying moisture contents until at least 3 points are obtained on the dry side of "optimum moisture" and at least two points are obtained on the wet side of "optimum moisture." This can usually be accomplished by compacting different specimens at moisture intervals of 2 to 3 percent, starting on the dry side of "optimum moisture" and ending on the wet side.

d.2.i. Remove the material from the mold and slice vertically through the center. Take a representative sample, weighing a minimum of 100 g[2], of the material from one of the cut faces, determine the mass immediately and dry in accordance with KT-11, to determine the moisture content.

d.3. Calculations:

$$w = \frac{A - B}{B - C} \times 100$$

and

$$W = \frac{W_1}{w + 100} \times 100$$

where:

w = percentage of moisture in the specimen, based on oven dry mass of soil

A = mass of container and wet soil

B = mass of container and dry soil
C = mass of container

W = dry mass, in kilograms per cubic meter of compacted soil, or pounds per cubic foot of compacted soil

[2] The masses given in **d.2.i.** & **e.2.g.** are taken from AASHTO T - 265.

W_1 = wet mass, in kilograms per cubic meter of compacted soil, or pounds per cubic foot of compacted soil

Where:

$W_1 = (A - C)F$

F = 30 for the 4 in mold and 13.33 for the 6 in mold (see **e.2.e**.) (1060 for 101.6 mm mold and 471 for 152.4 mm mold)

d.4. Compaction Curve: Plot a density/moisture curve on coordinate paper (KDOT Form No. 638) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissae and a smooth curve is drawn to best fit the points.

NOTE: In drawing a curve by this method, all of the points will not necessarily be on the curve and the maximum density may be more or less than the highest test point. (See example at the end of this test method.)

The optimum moisture content is the moisture content at which the maximum density occurs on the curve.

The data for this test may be recorded on the "Work Sheet for Standard Compaction Tests" (KDOT Form No. 676) which is in bound book form.

e. GRANULAR MATERIALS

e.1. Sample Preparation.

e.1.a. Obtain approximately 100 lb (45 kg) of the material to be tested, dry to maximum of 140^0 F if necessary and pulverize in such a manner as to avoid reducing the natural size of individual particles.

e.1.a.1. Sieve an adequate quantity of the pulverized soil over the $^3/_4$ in (19.0 mm) sieve. Discard the coarse material, if any, retained on the $^3/_4$ in (19.0 mm) sieve.

e.1.b. Thoroughly mix and weigh out six portions, each weighing 16 lb (7 kg).

e.2. Test Procedure

e.2.a. Add a measured amount (approximately 5 percent) of water and thoroughly mix with one 16 lb (7 kg) portion. After the addition of water and thorough mixing, the sample shall be placed in a covered container and allowed to stand for a minimum of 2 hours before conducting the moisture-density test.

e.2.b. Place the assembled mold on the rigid base and fill in three approximately equal layers. Compact each layer with 56 blows of the rammer with the blows being distributed uniformly over the surface of the layer.

e.2.c. After the third layer has been compacted, remove the collar and trim excess material level with the top of the mold.

e.2.d. Remove the base and trim excess material level with the bottom of the mold.

e.2.e. Weigh the sample while it is in the mold and multiply the mass of the sample and the mold, minus the mass of the mold, by 13.33 (471), and record the result as the wet density, W_1, in pounds per cubic foot, (kilograms per cubic meter), of the compacted soil.

e.2.f. Repeat the compaction procedure using the other 16 lb (7 kg) increments of the sample to which different measured amounts of water have been added, thoroughly mixed and cured as in **e.2.a.** This procedure will be continued with varying moisture contents until at least 3 points are obtained on the dry side of "optimum moisture" and at least two points are obtained on the wet side of "optimum moisture". This can usually be accomplished by compacting different specimens at moisture intervals of 2 to 3 percent, starting on the dry side of "optimum moisture" and ending on the wet side.

e.2.g. Remove the material from the mold and slice vertically through the center. Take a representative sample, weighing a minimum of 300 g, of the material from one of the cut faces, determine the mass immediately and dry in accordance with **KT-11**, to determine the moisture content.

e.3. Calculations.

e.3.a. The calculations used are given in **d.3.** of this specification.

e.4. Compaction Curve: Plot a density/moisture curve on coordinate paper (KDOT Form No. 638) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissae and a smooth curve is drawn to best fit the points.

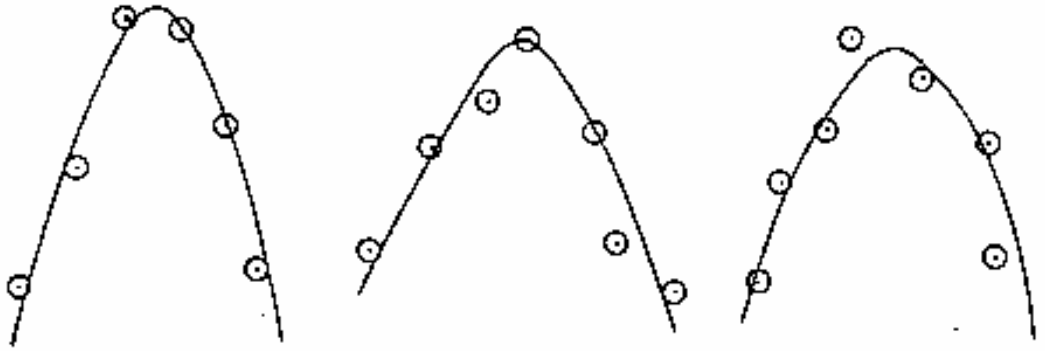
NOTE: In drawing a curve by this method all of the points will not necessarily be on the curve and the maximum density may be more or less than the highest test point. (See examples at the end of this test method.)

The optimum moisture content is the moisture content at which the maximum density occurs on the curve.

The data for this test may be recorded on the "Work Sheet for Standard Compaction Tests" (KDOT Form No.676) which is in bound book form.

COMPACTION CURVE EXAMPLES

CORRECT



INCORRECT